Treatment Technologies

Description

Treatment technologies are chemical, biological, physical, or thermal processes that can clean up hazardous waste or contaminated materials. Treatment technologies can destroy contaminants in waste or change them to reduce the amount of contaminated material, or remove or immobilize the hazardous component of the waste.

EPA distinguishes between established and innovative technologies based mainly on differences in the cost and amount of performance data available for them. Established technologies are those that have been used at many different types of sites and the results have been fully documented. Examples of established technologies are incineration, solidification, and pump and treat. Innovative technologies are newer processes that have been used to treatment hazardous waste but still lack sufficient information about cost and performance to predict their effectiveness under a variety of site conditions. By 1990, 40% of the treatment technologies used at hazardous waste sites were innovative, and in just four years that figure rose to almost 60%. The most frequently used innovative technologies are: chemical dehalogenation; soil vapor extraction; air sparging; bioremediation; thermal desorption; soil washing; solvent extraction; and *in situ* soil flushing.

Using the Resource

The following summaries briefly describe commonly used treatment technologies. For a more detailed information on a technology, consult one of the resources listed at the end of this section.

Most Frequently Used Treatment Technologies

- **Activated Carbon Treatment**
  Activated carbon treatment is used to treat organic contaminants in waste streams by pumping the streams through a filter of carbon granules. After a certain length of time, all the surface area inside the pores of the granules is covered, and the filter is said to be saturated or spent. At this point, the carbon in the filter must be replaced or regenerated. This regeneration is usually accomplished by heating the carbon and passing an air stream through it. The heat loosens the organic molecules, and the air stream sweeps them away. The loose organic molecules are subsequently collected and treated or destroyed.

- **Capping**
  Capping is used to cover buried waste materials and prevent migration of contaminants in the waste. This migration can be caused by rainwater or surface water moving over or through the site, or by the wind. Caps are generally made of a combination of materials, such as synthetic fibers, heavy clays, and sometimes concrete.

- **Immobilization**
  Immobilization prevents chemicals, found in soil slurries and waste sludges, from spreading to the surrounding environment. This treatment process binds the chemicals into an immobile, insoluble mass that minimizes the surface area of the waste chemicals exposed to migration through leaching. Leaching is caused when water, either surface water or groundwater, moves through wastes (much as water percolates through coffee grounds) picking up contaminants and spreading them to uncontaminated areas.

- ***In Situ* Vitrification**
  In Situ vitrification (ISV) uses extremely high temperatures (ranging from 2,900°F to 3,600°F) to melt waste and soils or sludges into a glassy, solid mass that is resistant to

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leaching. The solid mass is more durable than either granite or marble. ISV destroys organic (carbon-containing) pollutants and immobilizes and traps inorganic pollutants. It destroys organic pollutants by a process known as "pyrolysis," which chemically decomposes the substances through heat. Although ISV was developed initially to stabilize previously disposed radioactive wastes, it is also used to destroy or immobilize many organic and inorganic chemicals wastes, such as heavy metals, polychlorinated biphenyls (PCBs), process sludges, and plating wastes.

- **Incineration**
  Incineration destroys hazardous organic compounds, such as dioxins and PCBs, in soils, sludges, solids, and liquids. Incineration reduces toxic elements to basic elements, mainly hydrogen, carbon, chlorine, and nitrogen, at high temperatures (between 1,600°F and 2,500°F). The basic elements combine with oxygen to form stable non-toxic substances, such as water, carbon dioxide, and nitrogen oxides.

- **Pump and Treat**
  Pump and treat is the most common cleanup technology used to purify contaminated aquifers. Aquifers are natural, underground rock formations capable of storing large amounts of water. The pump-and-treat process usually involves recovering contaminated groundwater from the aquifer through recovery walls, treating the recovered water, discharging the treated water, and disposing of the contaminants.

- **Soil Vapor Extraction**
  Soil vapor extraction (SVE), a relatively simple process that physically separates contaminants from soil, is the most frequently used innovative treatment at Superfund sites. As the name suggests, SVE extracts contaminants from the soil in vapor form. Therefore, SVE systems are designed to remove contaminants that have a tendency to volatilize or evaporate easily. SVE removes volatile organic compounds (VOCs) and some semi-volatile organic compounds (SVOCs) from soil beneath the ground surface in the unsaturated zone—that part of the subsurface located above the water table. By applying a vacuum through a system of underground wells, contaminants are pulled to the surface as vapor or gas. In addition to the vacuum extraction wells, air injection wells can be installed to increase the air flow and improve the removal rate of the contaminant. An added benefit of introducing air into the soil is that it can stimulate bioremediation of some contaminants.

  SVE is sometimes called *in situ* volatilization, enhanced volatilization, *in situ* soil venting, forced soil venting, *in situ* air stripping, or soil vacuum extraction.

- **Air Sparging**
  Air sparging is used in conjunction with soil vapor extraction to remove contaminants in the saturated zone of the subsurface, which is the water-soaked soil that lies below the water table. Air sparging pumps air into the saturated zone to help flush (bubble) the contaminants up into the unsaturated zone where the SVE extraction wells can remove them. The soil in the saturated zone must be loose enough to allow the injected air to readily escape up into the unsaturated zone. Air sparging, therefore, works best at sites with coarse-grained soil, like sand and gravel.

- **Bioremediation**
  Bioremediation uses naturally occurring microorganisms (yeast, fungi, or bacteria) to break down, or degrade, organic contaminants into less toxic or nontoxic substances—mainly carbon dioxide and water. After the contaminants are degraded, the population of

microorganisms reduces because their food source is depleted. Dead microorganisms or small remaining microbial populations pose no contamination risk.

- **Soil Washing**
  Soil washing uses liquids (usually water, sometimes combined with chemical additives) and a mechanical device to scrub soils. Scrubbing removes hazardous contaminants and concentrates them into a smaller volume. Hazardous contaminants tend to bind, chemically and physically, to silt and clay. Silt and clay, in turn, bind to sand and gravel particles. The soil washing process separates the contaminated fine soil (silt and clay) from the uncontaminated coarse soil (sand and gravel). When completed, the smaller volume of soil, which contains the majority of the fine silt and clay particles, can be further treated by other methods (such as incineration or bioremediation) or disposed of according to State and Federal regulations. The larger, non-toxic volume of coarse soil can be used as backfill.

- **Chemical Dehalogenation**
  Chemical dehalogenation removes halogens (usually chlorine) from a chemical contaminant, rendering it less hazardous. Halogens are in a class of chemical elements that includes chlorine, bromine, iodine, and fluorine. The chemical dehalogenation process can be used on common halogenated contaminants, such as PCBs and dioxins, which are usually found in soil and oils.

- **Solvent Extraction**
  Solvent extraction uses a solvent (a fluid that can dissolve another substance) to separate or remove hazardous organic contaminants from sludges, sediments, or soil. (Sludge is a mud-like material produced from industrial or sewage waste, and sediment is fine-grained rock and mineral fragments that have settled to the bottom of a water body such as a river or lake.) Rather than destroy contaminants, solvent extraction concentrates them so they can be more easily recycled or destroyed by another technology.

- ***In Situ* Soil Flushing**
  In situ soil flushing is an innovative treatment technology that floods contaminated soils with a solution to move contaminants to an area where they can be removed. *In situ*, which means "in place," refers to treating the contaminated soil without it digging up. The specific contaminants in the soil at any particular site determine the type of flushing solution needed in the treatment process. The flushing solution is typically one of two types: water only; or water plus additives, such as acids (low pH), bases (high pH), or surfactants (like detergents).

- **Natural Attenuation**
  Natural attenuation uses natural processes to contain the spread of contamination from chemical spills and reduces the concentration and amount of pollutants at contaminated sites. Natural attenuation—also referred to as intrinsic remediation, bioattenuation, or intrinsic bioremediation—is an *in situ* treatment method. Environmental contaminants are left in place while natural attenuation works on them. Natural attenuation is often used as one part of a site cleanup that also includes the control or removal of the source of the contamination.

- **Phytoremediation**
  Phytoremediation is the use of plants and trees to clean up contaminated soil and water. Growing and sometimes harvesting plants on a contaminated site is an aesthetically pleasing, solar-energy driven, passive remediation technique. It that can be used in place of mechanical cleanup methods or in conjunction with these methods. Phytoremediation

can be used to clean up metals, pesticides, solvents, explosives, crude oil, polyaromatic hydrocarbons, and landfill leachates.

- **Treatment Walls**
Treatment walls are structures installed underground to treat contaminated groundwater. Treatment walls, also called passive treatment walls or permeable barriers, are installed by constructing a giant trench across the flow path of contaminated groundwater and filling it with one of a variety of materials (reactive fillings) carefully selected for their ability to clean up contaminants of concern. As the contaminated groundwater passes through the treatment wall, the contaminants are either trapped or transformed into harmless substances by the wall.

- **Thermal Desorption**
Thermal desorption is an innovative treatment technology that heats soils contaminated with hazardous wastes to temperatures of 200°F-1,000°F. The heat causes contaminants with low boiling points to vaporize (turn into gas) and, consequently, separate from the soil. (The other soil contaminants, if any, are treated by other methods.) The vaporized contaminants are collected and treated, typically by an air emissions treatment system. While thermal desorption physically separates contaminants from soil for later treatment, incineration destroys the contaminants.

Outside Sources of Information

See Internet, Tab 10

- Information on cleanup technologies is available from EPA's Clean-Up Information (*CLU-IN*) ***Internet*** Web site: *www.clu-in.org*

- Contact the Technology Innovation Office to obtain information on treatment technologies:

Address: Technology Innovation Office
Office of Solid Waste and Emergency Response (5102G)
U.S. EPA
401 M Street, S.W.
Washington, D.C. 20460

Telephone: (703) 603-9909/9910

- Contact TIO or *CLU-IN* to obtain copies of the following documents on treatment technologies:

- *A Citizen's Guide to Activated Carbon Treatment* EPA 542-F-01-020; Spanish EPA 542-F-01-020S
- *A Citizen's Guide to Air Stripping* EPA 542-F-01-016; Spanish EPA 542-F-01-016S
- *A Citizen's Guide to Bioremediation* EPA 542-F-01-001; Spanish EPA 542-F-01-001S
- *A Citizen's Guide to Capping* EPA 542-F-01-022; Spanish EPA 542-F-01-022S
- *A Citizen's Guide to Chemical Dehalogenation* EPA 542-F-01-010; Spanish EPA 542-F-01-010S
- *A Citizen's Guide to Chemical Oxidation* EPA 542-F-01-013; Spanish EPA 542-F-01-013S
- *A Citizen's Guide to Fracturing* EPA 542-F-01-015; Spanish EPA 542-F-01-015S
- *A Citizen's Guide to Incineration* EPA 542-F-01-018; Spanish EPA 542-F-01-018S

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- *A Citizen's Guide to In Situ Flushing* EPA 542-F-01-011; Spanish EPA 542-F-01-011S
- *A Citizen's Guide to In Situ Thermal Treatment Methods* EPA 542-F-01-012; Spanish EPA 542-F-01-012S
- *A Citizen's Guide to Monitored Natural Attenuation* EPA 542-F-01-004; Spanish EPA 542-F-01-004S
- *A Citizen's Guide to Permeable Reactive Barriers* EPA 542-F-01-005; Spanish EPA 542-F-01-005S
- *A Citizen's Guide to Phytoremediation* EPA 542-F-01-002; Spanish EPA 542-F-01-002S
- *A Citizen's Guide to Pump and Treat* EPA 542-F-01-025; Spanish EPA 542-F-01-025S
- *A Citizen's Guide to Soil Excavation* EPA 542-F-01-023; Spanish EPA 542-F-01-023S
- *A Citizen's Guide to Soil Vapor Extraction and Air Sparging* EPA 542-F-01-006; Spanish 542-F-01-006S
- *A Citizen's Guide to Soil Washing* EPA 542-F-01-008; Spanish EPA 542-F-01-008S
- *A Citizen's Guide to Solidification/Stabilization* EPA 542-F-01-024; Spanish EPA 542-F-01-024S
- *A Citizen's Guide to Solvent Extraction* EPA 542-F-01-009; Spanish EPA 542-F-01-009S
- *A Citizen's Guide to Thermal Desorption* EPA 542-F-01-003; Spanish EPA 542-F-01-003S
- *A Citizen's Guide to Vitrification* EPA 542-F-01-017; Spanish EPA 542-F-01-017S